What Doesn’t Kill You Makes You Richer: Adult Wages and the Early-Life Disease Environment in India

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what is the effect of early-childhood environment (nutrition, health, disease, socio-economic status) on adult outcomes (health, education, wages)?

this question is at the heart of a large literature, increasingly focussing on developing countries
Literature Overview

- Child Height & Health
- Adult Height & Health
- Early-life Disease & Net Nutrition Environment
- Cognitive Achievement
- Wages
Introduction

Literature Overview

Child Height & Health

Adult Height & Health

Early-life Disease & Net Nutrition Environment

Spears (2012), Brainerd & Menon (2013)

Cognitive Achievement

Wages
Introduction

Literature Overview

Early-life Disease & Net Nutrition Environment

Child Height & Health

Adult Height & Health

Bozzoli, Deaton & Quintana-Domeque (2009)
Quintana-Domeque, Bozzoli & Bosch (2011)

Cognitive Achievement

Wages
Introduction

Literature Overview

- Early-life Disease & Net Nutrition Environment
  - Maluccio et al (2009)
  - Spears & Lamba (2013)
  - Cognitive Achievement
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    - Child Height & Health
    - Wages
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Literature Overview

Early-life Disease & Net Nutrition Environment

Child Height & Health

Case & Paxson (2008)

Adult Height & Health

Cognitive Achievement

Wages
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References:
- Glewwe, Jacoby & King (2001)
- Alderman, Hoogeveen & Rossi (2009)
- Spears (2012)
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Vogl (2014)
Introduction

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Case & Paxson (2008), etc.
Early-life Disease & Net Nutrition Environment

Child Height & Health

Adult Height & Health

Cognitive Achievement

Wages

millions of papers

millions of papers
Introduction

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Early-life Disease & Net Nutrition Environment

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Cognitive Achievement

Wages

Lawson & Spears (2014)
Effect of Disease & Nutrition Environment on Wages

- previous studies answering a version of this question:
  - Hoddinott et al (2008), INCAP nutrition intervention in Guatemala
  - Barreca (2010), malaria exposure in US south
  - Cutler et al (2010), malaria eradication program in India in 1950s (effect on consumption)
  - Almond, Currie & Herrmann (2012), association between post-neonatal mortality and mothers’ outcomes in US
Our Question

- what is the effect of the early-life disease environment on adult wages in India?

  - important question in India, given prevalence of open defecation and stunting

  - we use IHDS data to examine how infant mortality rate and sanitation coverage experienced as a child are associated with adult wages

  - identification strategy: districts where improvements in disease environment have been steepest should be the districts where the wages of young workers are highest relative to the wages of old workers

  - then simple calculation of fiscal effects of improvements in IMR/sanitation, and estimated welfare impacts of sanitation investments
Summary Statistics

- individual data from 2004-05 India Human Development Survey
- historical district level data from Indian Census

**Table: Summary Statistics**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>25th percentile</th>
<th>75th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>hourly wage (rupees)</td>
<td>10.43</td>
<td>9.11</td>
<td>5.71</td>
<td>12.00</td>
</tr>
<tr>
<td>log of hourly wage (rupees)</td>
<td>2.12</td>
<td>0.62</td>
<td>1.74</td>
<td>2.48</td>
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<tr>
<td>infant mortality rate in birth year</td>
<td>113.0</td>
<td>41.9</td>
<td>81.3</td>
<td>137.6</td>
</tr>
<tr>
<td>sanitation coverage in birth year</td>
<td>16.8</td>
<td>25.7</td>
<td>0.0</td>
<td>34.0</td>
</tr>
<tr>
<td>birth year</td>
<td>1979.4</td>
<td>4.9</td>
<td>1975</td>
<td>1983</td>
</tr>
<tr>
<td>age in survey</td>
<td>25.6</td>
<td>4.9</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>urban</td>
<td>0.3</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>n (adult men)</td>
<td>12,783</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Empirical Results

Relationship Between IMR/Sanitation and Adult Wages

(a) effect of IMR, no controls
(b) effect of sanitation, no controls

(c) effect of IMR, with controls
(d) effect of sanitation, with controls
Regression Specification

- $\log(y_{tdsi}) = \beta h_{tds} + \gamma_t + \alpha_d + urban \times (\omega_s + g_i) + t_s + j_i + e_i$

- $h$ stands for either IMR or sanitation coverage in year of birth

- $t =$ time (year of birth), $d =$ district, $s =$ state, $g =$ social group, $j =$ job category, $e =$ education category
## IMR Regressions

**Table:** Regression of Wages on IMR

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IMR in birth year</strong></td>
<td>-0.00174*</td>
<td>-0.00195*</td>
<td>-0.00166*</td>
<td>-0.00170*</td>
</tr>
<tr>
<td></td>
<td>(0.000706)</td>
<td>(0.000796)</td>
<td>(0.000742)</td>
<td>(0.000699)</td>
</tr>
<tr>
<td><strong>district fixed effects</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>year of birth fixed effects</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>state × urban fixed effects</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>social group × urban indicators</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>state-specific linear time trends</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>job category fixed effects</strong></td>
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<tr>
<td><strong>education indicators</strong></td>
<td></td>
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<td></td>
<td>✓</td>
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</tbody>
</table>

*p values: † = 0.1, * = 0.05, ** = 0.01, *** = 0.001. Standard errors clustered at the district level.*
## IMR Regressions

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<th>(4)</th>
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</thead>
<tbody>
<tr>
<td>IMR in birth year</td>
<td>-0.00166**</td>
<td>-0.00167*</td>
<td>-0.00139*</td>
<td>-0.00156*</td>
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<tr>
<td></td>
<td>(0.000597)</td>
<td>(0.000718)</td>
<td>(0.000696)</td>
<td>(0.000673)</td>
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<tr>
<td>year of birth fixed effects</td>
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<td>12,783</td>
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## Sanitation Regressions

### Table: Regression of Wages on Sanitation Coverage

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
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<th>(5)</th>
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<tbody>
<tr>
<td>sanitation in birth year</td>
<td>0.00296***</td>
<td>0.00296</td>
<td>0.00181***</td>
<td>0.00322†</td>
<td>0.00286†</td>
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<tr>
<td></td>
<td>(0.000509)</td>
<td>(0.001611)</td>
<td>(0.000509)</td>
<td>(0.00169)</td>
<td>(0.00169)</td>
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<tr>
<td>state × urban fixed effects</td>
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<td>social group × urban indicators</td>
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<tr>
<td>education indicators</td>
<td></td>
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</table>

F<sub>16,322</sub> = 5.98

(p < 0.001)

n (adult men) 6,134 6,134 6,134 6,134 6,134

p values: † = 0.1, * = 0.05, ** = 0.01, *** = 0.001. Standard errors clustered at the district level.
Empirical Results

Why Might Controlling for Education Make So Little Difference?

-0.1 -0.05 0 0.05 0.1 0.15
adult literacy: residual after district and cohort fixed effects

early life infant mortality rate

Brahmin high caste OBC Dalit Adivasi Muslim Sikh or Jain Christian

-1 -0.5 0 0.5 1
adult literacy: residual after district and cohort fixed effects
### Table: Regressions of Schooling & Literacy on IMR & Sanitation

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>schooling</td>
<td>schooling</td>
<td>literacy</td>
<td>literacy</td>
</tr>
<tr>
<td>IMR in birth year</td>
<td>0.00175</td>
<td>0.00175</td>
<td>0.00057</td>
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<tr>
<td></td>
<td>(0.00508)</td>
<td>(0.00048)</td>
<td>(0.00048)</td>
<td>(0.00048)</td>
</tr>
<tr>
<td>sanitation in birth year</td>
<td>0.0215</td>
<td>0.0215</td>
<td>0.00102</td>
<td>0.00102</td>
</tr>
<tr>
<td></td>
<td>(0.0154)</td>
<td>(0.0154)</td>
<td>(0.00148)</td>
<td>(0.00148)</td>
</tr>
<tr>
<td>district fixed effects</td>
<td>✓</td>
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<td>✓</td>
</tr>
<tr>
<td>year of birth fixed effects</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>n (adult men)</td>
<td>12,718</td>
<td>6,134</td>
<td>12,747</td>
<td>6,142</td>
</tr>
</tbody>
</table>

*p values: † = 0.1, * = 0.05, ** = 0.01, *** = 0.001. Standard errors clustered at the district level.*
## Empirical Results

### Consumption vs. Hourly Wages

**Table: Comparing Coefficients for Wages and Consumption**

<table>
<thead>
<tr>
<th>dependent variable:</th>
<th>(1) hourly wage</th>
<th>(2) consumption</th>
<th>(3) consumption</th>
<th>(4) consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>sample:</td>
<td>full</td>
<td>full</td>
<td>main earner</td>
<td>not main</td>
</tr>
<tr>
<td>IMR in birth year</td>
<td>-0.00195*</td>
<td>-0.00152*</td>
<td>-0.00212*</td>
<td>0.000314</td>
</tr>
<tr>
<td></td>
<td>(0.000796)</td>
<td>(0.000646)</td>
<td>(0.000820)</td>
<td>(0.000983)</td>
</tr>
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<td>district fixed effects</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>year of birth fixed effects</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>n (adult men)</td>
<td>12,783</td>
<td>12,716</td>
<td>8,312</td>
<td>4,404</td>
</tr>
</tbody>
</table>

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Empirical Results

Quantile Regressions of Log Wages

-0.005 -0.004 -0.003 -0.002 -0.001

quantile coefficient on log wages

0.2 0.4 0.6 0.8 1

quantile

no controls age & urban & state FEs

quantile coefficient on log wages
Fiscal Effects

- If investments to improve sanitation and/or lower infant mortality raise wages and therefore consumption, they will lead to increases in the government’s tax revenues.

- Therefore, follow-up question: what will be the net fiscal impact?

- Consider an investment costing $c$ dollars today, but generating income gains of $g_t$ percent at future dates.

  - If government cares only about effect on net budget surplus, they should undertake the investment if the gain in tax revenues $T$, discounted appropriately ($\delta = \frac{1}{1+r}$), is greater than $c$:

    $$ c < \sum_{t=t_0}^{t_1} \delta^t [T((1 + g_t)y_t) - T(y_t)] $$


Estimated Fiscal Effects

- our preferred estimates indicate:
  - 10 point reduction in IMR (1% point) leads to wage increase of 1.74%
  - 10% point improvement in sanitation coverage raises wages by 2.96%

- thus, the simplest calculation of fiscal benefits would be to assume that government tax revenues increase by the same percent
  - given quantile regressions, this is likely conservative, as gains appear larger at higher incomes
Estimated Fiscal Effects

- Government revenues from income taxes, excise duties and service tax were approximately 5.11 trillion rupees ($82.3 billion US) in 2012-13.

- Assuming 40 years of working life, $2.06 billion from each year-of-birth cohort, and revenue gains per year are $36 million and $61 million.

- 3.85% real interest rate (8.9% minus inflation of 5.05%).

- Also ignore economic growth, which could seriously understate the effect.
Estimated Fiscal Effects

- now add up discounted revenue gains into the future
  - for 1% point reduction in IMR for all generations starting from today
  - and for complete elimination of open defecation today
start counting fiscal gains 18 years from now, phasing in year-of-birth cohorts one by one until complete after 57 years, run until 100 years from now

per-year revenue increase eventually reaches $1.43 billion

present value of revenue gains are $9.43 billion
Fiscal Effects of Elimination of Open Defecation

- again, starting counting fiscal gains 18 years from now, but now assume linear gains from elimination of open defecation

- allow for declining trend: open defecation rate 53.1% in 2011, but declining at average of 1.05% per year over previous decade, so assume this continues linearly without any intervention and open defecation would thus be eliminated in 2062

- revenue gains start at $323 million 18 years from now, peak at $4.25 billion in 43 years

- present value of revenue gains are $52.23 billion, or about $399 per household that defecates in the open
Analysis of Fiscal Effects

- these gains are substantial, and indicate that investments in reducing or eliminating open defecation that cost less than $399 per household that stops defecating in the open would not have any net cost to the government.

- and we ignore other fiscal gains from reduced health care expenditures, calorie requirements, etc.
Welfare Effects

- we can also estimate the effects of investments in sanitation on overall well-being (through income and consumption)

- assume individuals receive disutility $d \sim F(d)$ from latrine use, so the fraction $L = F(0)$ use a latrine

- but government can, for cost $c$ per unit, shift $L$ upwards (educate people to receive higher direct utility from using a latrine)
  - ignore welfare gains from changing preferences of inframarginal latrine users
Fiscal and Welfare Analysis

Welfare Effects

- assuming constant income/consumption, let $\sum_d = \delta^t_0 \frac{1 - \delta^{t_1 - t_0 + 1}}{1 - \delta}$ and $V = \sum_d E[U]$

- the welfare gain can be approximated:

$$\frac{dV}{dL} = \sum_d E \left[ MU[(1 - t(y)) \frac{dy}{dL} + E[t(y) \frac{dy}{dL}] - \frac{1}{\sum_d c} \right]$$

$$\frac{dW}{dL} \equiv \frac{dV}{E[MU]} = \sum_d \frac{E[MU(1-t(y)) \frac{dy}{dL}]}{E[MU]} + \sum_d E \left[ t(y) \frac{dY}{dL} \right] - c$$
Estimated Welfare Effects

- in simplest version ignoring distributional effects, just add increase in after-tax wages to fiscal gains

- consider an investment costing $399 per household, i.e. perfectly offsetting fiscal gains; then, with per-capita income of $1219, 10% point reduction in open defecation raises wages by $36 per male worker per year

- tax revenue as % of GDP was 10.39% in 2011, and I use discount rates of 3.85%
income gain for an individual born today would be $1830 in present value

with male workforce of 240 million (“main workers” from 2001 Census), total income gains are $166.71 billion

in future work we can examine robustness to distributional effects, and use estimated effects of sanitation on consumption
Conclusion

- We set out to answer the question of the effect of early-life sanitation/disease environment on adult wages.
- Lower IMR and better sanitation are associated with significantly higher adult wages.
- These wage gains translate into significant fiscal impacts.
- Eliminating open defecation today would generate additional government revenues of $52 billion in present value, and further income gains of as much as $167 billion.
THE END